

Case study: Brunei

SnapShot system enabled efficient underbalanced perforating in six wells

A new field development offshore Brunei had a fluid-sensitive, high-pressure/high-temperature (HP/HT) formation that presented many perforating challenges.

The operator needed a perforating strategy that would optimize both static and dynamic underbalance to eliminate potential formation damage, while optimizing production. And, with six wells to perforate, the operator required the minimum number of perforating runs per well.

After consulting Baker Hughes, the operator chose the **SnapShot™ advanced live-well deployment system** for the project, which consisted of both HP/HT and conventional wells.

The Snapshot system deploys perforating guns on coiled tubing under pressure, using special connectors and blowout preventers. The system enables virtually any length perforating gun assembly to be safely deployed and reverse-deployed without killing the well. This significantly reduces costs by eliminating the need for kill-weight fluids while reducing the number of perforating runs. Production is also enhanced by preventing damage from fluid loss.

Under-pressure design

Baker Hughes subject matter experts from tubing-conveyed perforating, lower completions, and coiled tubing, in addition to the local operations and technical personnel, worked closely with the operator to create

a single coiled tubing string design suitable for all six wells. Some exhibited expected formation pressures of 16,000 psi, which could theoretically reach approximately 14,000 psi wellhead pressure.

Using proprietary **CIRCA™** coiled tubing software and **PulsFrac™ dynamic event software**, and taking into account variations in well profile, reservoir pressure, degree of underbalance, gun lengths, and weights, they chose a high-yield (130,000 psi) heavy wall tapered (0.224 to 0.145 in) 1 3/4-in coiled tubing string.

Baker Hughes personnel also suggested running the safety valve wear sleeve “piggy back” on the motorhead assembly. This would remove the requirement for several slickline runs per well, saving in-well and surface equipment swapping time.

The team also looked at optimization of the perforating gun. A comprehensive plan of API Section II modified tests were conducted with a variety of perforating charges and downhole conditions to maximize the returns from the reservoir.

Additional computed tomography (CT) scans and computational fluid dynamic models were conducted to provide insight into the flow characteristics of the perforating tunnels.

The results of these tests enabled the operator to better understand the post-perforating tunnel characteristics and expected productivity.

Challenges

- Extreme levels of underbalance challenged historical coiled tubing collapse practices
- All retrieval operations under live well conditions
- HP/HT operation with potential wellhead pressures of 14,000 psi
- Project-specific string designed to cover six wells with one string make-up
- Mix of both HP/HT and conventional wells

Results

- Perforated more than 5,000 ft (1524 m) of zone in six live wells
- Installed and retrieved nearly 300 connections with 100% success
- Saved approximately 18 days of rig time over the six wells (\$900,000 USD)
- Reduced the need for additional slickline runs saving around \$150,000 USD per well
- Recorded zero HSE incidents

Flawless execution

Following training and personnel qualifications on test wells, operations commenced. On the first well, eight guns/hr were deployed (well unperforated) and live well retrieved at 0.7 guns/hr. As the campaign progressed, deployment times continued to improve to 15 guns/hr and live well retrieval rates of 2.4/hr. This was primarily associated with field crew continuity and their desire for flawless execution.

At the end of the first integrated Baker Hughes HP/HT coiled tubing advanced live-well deployment perforating project, all required zones on six wells had been perforated flawlessly.

More gun connections were deployed and recovered for this campaign than for all prior operations over the past 10 years combined.

During the 150 days on location, no HSE issues had occurred and a total of 18 days of rig time (\$900,000 USD value) had been saved by utilizing the wear sleeve.

The campaign earned letters of commendation from the customer, who has co-authored two SPE papers with Baker Hughes detailing aspects of the campaign and is actively considering the technology for other operating areas.



Baker Hughes perforated more than 5,000 ft of zone without killing the wells in a six-well campaign offshore Brunei.